EXAMINATION OF THE CITY OF DOVER FIRE STATION NEEDS

Strategic Management of Change

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ABSTRACT

In 1988, the Dover, New Hampshire Planning Department developed the City of Dover Master Plan. This plan outlined the need to build an additional fire station in the north end of the city. The problem is that members of the current City Council believe that once the proposed north end fire station is built then Central Fire Station will be closed. The purpose of this paper was to examine nationally accepted standards for fire and emergency medical service station locations to determine the feasibility of closing Central Fire Station and continue to maintain two fire stations for the entire city.

The project employed evaluative research to answer the following two questions: What nationally recognized standards apply to the locating of fire and emergency medical service stations? By applying these standards, would the building of a north end fire station at its projected site allow for the closing of Central Fire Station?

The research procedure employed was to determine what nationally recognized standards were available to justify the location of fire and emergency medical service stations. Finding none, a standard of travel distance was used that would allow responders to effect extinguishment before flashover is likely to occur and provide basic life support care in 4-minutes and advance life support care in 8-minutes for cardiac arrest victims.

The major finding of this study was that the ISO schedule used in completing the Master Plan is not an effective method of evaluating fire station locations. Further, the NFPA's recommended fire station location distances used in the Master Plan was not recommended by the NFPA.

The recommendation from this research was that Central Fire Station not be closed when the proposed north end station is built. Additional recommendations included the adoption of time and performance expectation standards by the City Council, exploration of a more useful method of data collection and the completion of a more comprehensive fire station evaluation using geo-based mapping software.

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INTRODUCTION

In 1988, the City of Dover, New Hampshire Planning Department developed the City of Dover Master Plan. Included in this plan were the projected needs for future fire station locations. The plan outlined the need to build an additional fire station in the north end of the city, in addition to maintaining Central Fire Station and South End Fire Station. In 1997 the City of Dover secured a parcel of land in the north end of the city in anticipation of building a new fire station in fiscal year 2003. The problem is that members of the current City Council believe that once a fire station is built in the north end of the city, Central Fire Station, covering the downtown, could be closed. The position of the members of the City Council conflicts with the recommendations outlined in the city's Master Plan.

The purpose of this paper was to examine nationally accepted standards for fire and emergency medical service station sites to determine the feasibility of closing Central Fire Station so as to continue to maintain two fire stations for the entire city. The project employed evaluative research to answer the following two questions:

1. What nationally recognized standard(s) apply to the location of fire and emergency medical service stations?
2. By applying these standards would the building of a north end fire station at its projected site allow for the closing of the Central Fire Station?

BACKGROUND AND SIGNIFICANCE

The City of Dover is spread over 28.3 miles in the Seacoast area of New Hampshire. With a population of 26,800 people, Dover citizens are provided fire protection and advanced life support (ALS) services by a full-time career department. Dover currently has two fire stations and has an Insurance Services Office Rating (ISO) of 4. Central Fire Station, built in 1899, houses the first responding fire apparatus for the downtown and the north end of the city. The first due ALS ambulance for the entire city also responds from this station. South End Fire Station, built in 1967, houses the first responding fire apparatus for the south end of the city, the west side industrial park and the turnpike. It also houses the first due aerial platform, the back up ALS unit, the rescue boat and the medium-duty rescue vehicle.

In 1988, the City of Dover, New Hampshire Planning Department developed the City of Dover Master Plan. Included in this plan were the projected needs for future fire station locations. The plan outlined the need to build an additional fire station in the north end of the city, in addition to maintaining Central Fire Station and South End Fire Station. The plan "recommended that a third fire station be constructed immediately" and it further recommended that the "fire station be located on Sixth Street, near the Sixth Street connector " ("City of Dover," 1988, p. 50).

The developers of the Master Plan endorsed the addition of the third fire station in the north end of the city based on a "National Fire Protection Association recommendation that a first due engine company (first arrival apparatus), be located within two miles of a residential area, and one and one-half miles of a commercial area" ("City of Dover," 1988, p. 47).

Additionally, the Master Plan developers cited a schedule from the ISO that states: "For maximum credit in the schedule, all sections of a city should be within one and one-half miles of an adequately equipped engine company and two and one-half miles of an adequately equipped ladder, service, engine-ladder, or engine service company" ("City of Dover," 1988, p. 47).

The criteria used to select the area of Sixth Street, near the Sixth Street connector, for the third fire station was based on the "number of households within a three minute response zone; proximity to high risk areas such as industrial zones and areas of low fire hydrant water pressure; proximity to turnpike access; and availability of one to two acres of land" ("City of Dover," 1988, p. 50).

The City of Dover Master Plan was accepted and endorsed by both the City of Dover Planning Board and the Dover City Council ("City of Dover," 1988). However, as a consequence of the economic downturn experienced by Dover in the late 1980s and into the early 1990s, the north end fire station was not built as recommended.

As a result of extensive industrial and residential growth in the north end of the city in the past two years, along with the projection for future north end growth, renewed interest in a north end fire station developed. In 1997 the city secured a parcel of land in the north end of the city, on the corner of Sixth Street and the Sixth Street connector. The parcel of land, a 3.38-acre lot, was set aside by the City

Council for the construction of a north end fire station. The lot was an end parcel and was part of a Community Development Block Grant subdivision consisting of single-family homes. This site was chosen as a result of the recommendation given in the 1988 Master Plan. Due consideration was also given to the fact that this subdivision would be a new subdivision. Anyone interested in living in this subdivision would be aware of the city's plan to build a fire station on the remote site of the subdivision. The Fire Chief and the Mayor, a retired police chief, were well aware of the observations made by another fire chief: "There are a few hard and fast rules we live by in the fire service. First, you cannot put a new fire station in an existing neighborhood. Second, you cannot take a fire station out of an existing neighborhood" (as cited in Gay & Siegel, 1987). In January 1998, a new City Council and Mayor took office and only two incumbents were re-elected.

In the course of delivering the FY1999-2005 Capital Improvement Program (CIP) presentation to the City Council in April 1998, the 1.3 million-dollar allocation for the building of a new north end fire station in fiscal year 2003 was introduced. In addition, $100,000 was requested for FY 2003 through the CIP to renovate the Central Fire Station. Central Fire Station was built in 1899 and in FY2003 it will have been nearly 25 years since its last renovation. It was during the CIP presentation that the City Council expressed its opinion that Central Fire Station would be closed once the north end fire station was built. Members of the City Council felt that there would be no need for three fire stations in the city; that the proposed north end fire station could adequately cover the area currently served by

Central Fire Station. The Mayor stated that he was under the impression that a new trend in fire station location was to locate fire stations outside the downtown area and to respond into the city, as opposed to being in the downtown and responding to the outskirts.

It is understandable that the elected officials would question the addition of another fire station. With tight budget constraints “many elected government officials are hard-pressed to justify an increase in expenditure or services unless it can be directly attributed to quantifiable improvement in service delivery to the community” (Bruegman & Coleman, 1997, p.83).

Was there a new trend or standard in fire station location that would allow for the elimination of the downtown fire station once the north end station was built? Additionally, the criteria used in the 1988 Master Plan for outlining the need for fire stations in the city did not consider the fact that the Dover Fire & Rescue Service also provides full advanced life support and emergency medical transport services. Were there separate standards or criteria for the siting of fire station facilities that also provide for emergency medical response? Given that “a master plan produced ten years ago may now be badly outdated” (Lewis, 1986a, p. 1), the answers to these questions provided the basis to revisit the fire station locations outlined in the 1988 Master Plan. Answers to these questions also allow for consideration of the possibility of building a north end station and closing Central Fire Station.

More than 25 years ago, fire station planning was prioritized as “one of the most important responsibilities of the fire department” (Gratz, 1972, p. 91). The inevitability of facing this responsibility is as applicable today as it was in 1972 and is "a task which virtually all municipalities or local governments have to face" (Marianov, 1990, p.1). Lewis (1986b), cited his opinion regarding fire station locations as follows:

> In few areas of public policy can the question of site location be as important as it is in the fire services. Inappropriately sited fire stations will result in inadequate fire protection, and consequent loss of lives and property in the event of a fire. (p.18)

The importance of properly placed fire stations was stressed further by Holland (1993) when he wrote "the allocation of fire suppression units and companies is a barometer of fire service's effectiveness, efficiency and cost to the city" (p. 7). Failure to effectively position fire stations will have a direct impact on the effectiveness of fire and EMS service delivery. While many individuals and agencies share in the delivery of fire protection services, "the executive fire officer is responsible for the direction of resource allocation to provide a level of service to protect the community" (Cato, 1990, p. 2).

This research project addresses the issue of Managing Change, Module 3 of instruction in the Strategic Management of Change course at the National Fire Academy.

LITERATURE REVIEW

A literature review was performed to examine pertinent published material with respect to fire station location planning and emergency medical service station planning. To compile this information, resource material was obtained from the Learning Resource Center at the National Fire Academy, the International City/County Management Association's InQuiry Service, the City of Dover Fire & Rescue Service library, the Dover Planning Office, the Internet and private home libraries.

The first issue addressed was a review the 1998 City of Dover Master Plan ("City of Dover," 1988). This was accomplished to determine which standards were used to make the recommendation to build a north end fire station and how they were applied. Two nationally recognized fire service authorities were quoted in the master plan as agencies that have established fire station location standards. The National Fire Protection Agency (NFPA) was quoted as "recommending a first due engine company (first arrival apparatus), be located within two miles of a residential area, and one and one-half miles of a commercial area" ("City of Dover," 1988, p. 50). According to the NFPA's internet site, the NFPA is an organization with a mission to "reduce the burden of fire on the quality of life by advocating scientifically based consensus codes and standards, research and education for fire and related safety issues" (NFPA Home Page, 1998).

The Insurance Services Office (ISO) schedule quoted was from Item 560 of the Insurance Services Office's Fire Suppression Rating Schedule, Edition 6-80 (Hickey, 1993). The Master Plan stated: "For maximum credit in the schedule, all sections of a city should be within one and one-half miles of an adequately equipped engine company and two and one-half miles of an adequately equipped ladder, service, engine-ladder, or engine service company" ("City of Dover," 1988, p. 47). The ISO is a nationwide nonprofit service organization that provides services to the property casualty insurance industry and through its subsidiary corporation, the Commercial Risk Services, evaluates public fire protection services (Coggan, 1995).

Other fire station location studies were compared with Dover's Master Plan to determine what standards other communities used to determine fire station site locations for their community. The Fire Station Location Study For The Evanston Fire Department cited the NFPA recommendation in determining travel distance between stations and the report termed the NFPA recommendation a "National Standards [sic]" (Gay, Rule & Siegel, 1987, p. 28). While ISO was referred to in the study, it was cited in context to training requirements. The City of Station 12 Relocation Study cited "ISO response criteria" ("City of La Mesa Study," 1989, p.35) as one of the steps used in the relocation process. The NFPA was referred to in the study but not in context of fire station location criteria.

The Lodi Fire Department Fire Station Master Plan stated that fire station location "construction will be on the basis of… criteria established by the Insurance Services Office" ("Lodi Master Plan," 1989, p. 2). The NFPA Handbook, 16th Edition, was cited in the appendix concerning the author's review of response time analysis work, conducted by the Southwest Research Institute, however, no mention of the NFPA recommendation for response distances was found.

The City of Champaign Fire Station Placement Study cites ISO guidelines for "maximum travel distance from both residential and commercial areas" (Pyrotech Consultants, Inc., 1990, p. 3). The NFPA is not referred to in this study. Finally, the South Portland, Maine Report Relative To The Fire Department cites both the ISO station location standard and the NFPA recommendation (MMA Consulting Group, Inc. 1997), contained in the 1988 City of Dover Master Plan.

While each of these communities, along with the City of Dover, used either the ISO criteria for fire station location or the NFPA's recommendation for fire station location or both, it should also be noted that other factors, in addition to ISO and NFPA, were often cited in these studies. Yet, though many communities used the ISO schedule or NFPA recommendation for determining fire station locations, the use of the ISO criteria or the NFPA recommendation may be inadequate for optimum fire station locations. For instance, regarding the ISO criteria for evaluation of fire station planning Coggan (1995) wrote: "The current classification system is not intended to present a complete analysis of the public fire protection needs of a city and should not be used for such an evaluation" (180). Further, Hickey (1993) wrote:

> The insurance industry's evaluation of a city's fire protection system is exclusively related to protecting the industry's interest on property loss…. Although this has to be an important consideration for the insurance industry, the actual fire protection needs for a city may be different from those of the

insurance industry. At a minimum, alternative considerations should be understood and examined when fire station location is an issue. (p. 221)

As for the NFPA recommendation for fire station location cited in the above-referenced studies, this recommendation is taken from the NFPA's Fire Protection Handbook, 14th Edition, published in 1976. McKinnon (1976) wrote that "response distances for the first due engine company must be not over 1 ½miles, except that it may be 2 miles in residential districts of 1- and 2-family dwellings…" (p. 9-78). In context, the author of Chapter 9 of the Handbook was simply providing an overview of the requirements of the then current ISO schedule requirements, the 1974 ISO schedule. There was no statement of recommendation from the NFPA in this section of the Handbook regarding fire station locations. Subsequently, the 15th through the 18th Editions of the Fire Protection Handbook, published from 1981-1997, did not contain language for fire station location distances from either the 1974 ISO schedule or the revised 1980 ISO schedule. Of particular interest was that the 15th Edition of the Handbook, the first edition published following the revision of the ISO schedule in 1980, did not contain the new ISO schedule for fire station location.

While subsequent editions of the Handbook do not address the reason that the ISO fire station location schedule are not detailed, the 17th Edition, under the section Public Protection Classifications, Granito (1991) made this statement:

For many years material developed by NFPA has been used in the analysis of services provided by fire protection organizations. However, the application of

> NFPA materials has been inconsistent, and NFPA material existing in 1991 is not entirely adequate for evaluation of the comprehensive services provided by comprehensive fire/rescue agencies. (p. 10-43)

The NFPA stated that its own material, available prior to 1991, was not entirely adequate for evaluation of fire protection services. Therefore, one could conclude from this statement that material published in 1976, the year the 14th Edition of the Handbook was published, could also be inadequate for fire station location planning. Further issue could be raised for not using the fire station distance criteria contained in the 14th Edition due to the fact that reference to fire station location was merely a summation of the 1974 ISO grading schedule. The 1974 ISO schedule, summarized in the 14th Edition, was rewritten in 1980. Yet no attempt has been made by the NFPA to publish the updated ISO travel distance schedule for fire station locations in subsequent NFPA Handbook Editions. Therefore, one could conclude that the NFPA does not recommend specific travel distance for fire station locations, rather "each community must decide the appropriate response and travel times for their community" (Barr & Caputo, 1997, p. 10-43).

Eliminating the use of the NFPA recommendation from Dover's 1988 Master Plan appears to be justified. Questioning the value of the ISO schedule as an evaluation tool, based on Coggan's (1995) admonition that it "should not be used for such an evaluation" (p. 180) and Hickey's (1993) recommendation that "alternative considerations should be… examined when fire station location is an issue (p. 221), also appears justified. In fact, Holba (1980) stated that: …ISO, to my knowledge, has never claimed their grading schedule to be a design tool in the locating of fire stations" (p. 35).

When it comes to national standards for fire station locations, "there are few standards regarding the optimum number and placement of fire stations in a community" (Gay & Siegel, 1987, p. 1). A more recent source observed that "currently there are no national standards for either response time or travel time" (Barr & Caputo, 1997, p. 252). So with no national standards to evaluate fire station location, "essentially each community must decide the appropriate response and travel times for their community" (Barr, Caputo, 1997, p. 10-251).

What then would be considered the appropriate response and travel time for the citizens of Dover? In the NFPA's Fire Projection Handbook, 18th Edition, Barr & Caputo (1997) suggest:

> The time selected must provide a balance between good service and the financial ability of the community to provide the necessary stations and resources. When a community selects a longer travel distance, it is willing to accept a larger risk level. (p. 10-252).

The International Association of Fire Chiefs (IAFC) (1995) states that fire stations be distributed "to assure rapid response deployment to minimize and terminate emergencies" (p. 6-4). The IAFC further defines an acceptable distribution policy as one that includes "benchmarks for intervention such as arrival prior to or at flashover and arrival on EMS incidents prior to brain death in cardiac arrest" (p. 6-4).

The City of Dover Fire & Rescue Service provides both fire protection services and advanced life support EMS services. As a result, both benchmarks described above needed to be investigated to determine when flashover occurs and when brain death occurs in cardiac arrest victims. By determining these times, acceptable response times to these types of emergencies could be addressed. Response times could then be converted to travel distance because “there is a direct mathematical correlation between response distance and response time” (Hickey, 1993, p. 222).

To establish an effective fire response travel distance criteria, the subject of flashover was considered. Francis L. Brannigan (1993), a noted expert on building construction and fire effects on buildings, defined flashover this way. “Flashover is defined as the stage of a fire at which all surfaces and objects in a room or area are heated to their ignition temperature and flames develop on all contents and combustible surfaces at once” (p. 13).

The MMA Consulting Group, Inc., in its report for the City of South Portland, Maine (1997), provided a more expanded explanation of flashover as follows:

> Flashover is a rapid transition in fire behavior from localized burning of fuel, to involvement of all the combustibles in the enclosure. At flashover, fire typically expands in six different directions: vertically through the ceiling, horizontally through the four walls, and even through openings in the floor. At that time, all barriers to fire growth beyond the original compartment are under attack by

> extremely hot flame, smoke and gasses which expand at approximately 50 times their volume per minute. (p. 29)

Coughlin and Penner (1991) explain the significance of initiating extinguishment efforts prior to the time a fire reaches flashover as follows:

> Flashover is a critical stage of fire growth for two reasons. First, no living thing in the room of origin will survive, so the chances of saving lives drops dramatically. Second, flashover creates a quantum jump in the rate of combustion, and significantly greater amount of water is needed to reduce the burning material below its ignition temperature. A fire that has reached flashover means its to [sic] late to save anyone in the room of origin, and a lot more manpower is required to handle the larger hose streams needed to extinguish the fire. A post-flashover fire burns hotter and moves faster, compounding the search and rescue problems in the remainder of the structure at the same time that more firefighters are needed for fire attack. (p. 19)

However, to establish an exact timeframe for when flashover will happen during a fire is difficult to determine. This is because "there are a number of factors that determine when flashover may occur. These include the type of fuel, the arrangement of the fuels in the room, room size, etc." (Barr & Caputo, 1997, p. 10-250). Because of these varying factors Barr and Caputo (1997) stated that "flashover cannot be predicted" (p. 10-250). However, another source documented "comprehensive testing by the United States Institute of Standards and Technology has established that a fire within a typically furnished room will evolve into flashover within four to ten minutes of the event of open flame… United States fire department planning generally recognizes approximately an eight-minute period before flashover" ("MMA Consulting Group, Inc.," 1997, p. 29). The IAFC (1995) agrees with this time frame for flashover to occur during a fire ("Self Assessment," p. 6-35). The International Association of Fire Firefighters (IAFF) also agreed with this timeframe (1995a).

To establish an effective ALS and BLS response travel distance criteria, the subject of brain death was considered. In understanding the importance of providing life support measures before brain death occurs, one must understand the difference between clinical death and biological death. Grant, Murray and Bergeron (1994) explain:

> Clinical Death – *A patient is clinically dead the moment breathing and heartbeat stop.*
>
> Biological Death – *A patient is biologically dead when the brain cells die.* If a patient is not breathing and the heart is not circulating oxygenated blood, potentially lethal changes begin to take place in the brain within 4 to 6 minutes; brain cells usually begin to die within 10 minutes. (p. 104)

The American Heart Association's Heartsaver Manual, (as cited in Barr & Caputo, 1997) reported that a person's chances of surviving cardiac arrest are four times greater if a victim receives cardiopulmonary resuscitation (CPR) within the first four minutes of cardiac arrest. The CardioPulmonary Resuscitation guide further reported that “these actions must be promptly followed by defibrillation and advanced life support within the first eight minutes. As time increases, the survival rate decreases ultimately resulting in permanent brain damage and biological death” (Effron, 1997, p. 9).

As such, it can be concluded that there is a direct correlation between survivability of cardiac arrest and the time it takes for basic and advanced life support to begin. A 1993 study, known as the Eisenburg Study (as cited in “IAFF,” 1995a), studied 1,667 cardiac arrest victims. From that study, the ability for predicting survivability of cardiac arrest victims, based on timed intervention and emergency care, is showed as it appeared in the IAFF (1995a) manual as follows:

Survival Rate = 67% less (2.3% per minute to CPR)
less (1.1% per minute to defibrillation)
less (2.1% per minute to ACLS)

Based on the Eisenburg Study, it can be concluded that one-third of all cardiac arrest victims will die, regardless of what measures are taken to prevent death. With each passing minute beyond four minutes, the victim’s survivability chances go down 5.5% if no life support measures are initiated. The sooner a response agency or bystander can initiate CPR, the greater the chances of survival. Therefore, both the IAFC (1995) and the IAFF (1995a) concur that response to cardiac arrest victims should be within four minutes for basic life support and eight minutes for advanced life support.

Accordingly, a direct relationship between responding to fires and responding to advance life support calls can be made. The IAFF (1995a) concluded that:

> The critical time intervals for both EMS and fire responses are similar. In fire suppression, the time between ignition and full involvement of the room of the fire's origin is 8 to 10 minutes. Attacking a fire within this time substantially reduces fire damage. In cardiac arrest, brain death typically occurs within 8-10 minutes. The time between cessation of the heart beat and initiation of CPR, defibrillation, and ACLS determines the patient's chances of survival. (p. 7)

It can therefore be reasonably concluded that a four-minute response time for basic life support and an eight-minute response time for fires and advance life support can be used as a standard of service. However, other elements of response time needed to be taken into account beyond the time it takes to get from the fire station to the emergency incident. This is because response time was defined as "the total elapsed time between obtaining a verifiable address in the communications center and the arrival of trained personnel" ("IAFF," 1995b, p. 5).

The IAFC (1995) reported that response time begins at the time the alarm is received, and include the time necessary to process the call, turnout time of responding apparatus and travel time of the equipment to the incident. Barr and Caputo (1997) added to response time to include access time, the time necessary to reach the victim or fire, and set-up time, the time necessary to position apparatus.

The IAFC (1995) has set benchmarks for the amount of time it should take to receive a call for service and to process the call, 50 seconds. The IAFC has also established a benchmark for the amount of time it should take emergency responders to “discontinue the activities they are engaged in, properly attire themselves and board the vehicle in readiness for response” (p. 6-39). This is turnout time and the IAFC (1995) has determined this should take no more than 60 seconds. Many variables contribute to access time and set-up time, i.e.: size and type of the building, location of the emergency in the building, etc., and can only be determined by completing a thorough analysis of several different types of incidents (Barr & Caputo, 1997). The IAFC (1995) suggests a set-up duration of 30 seconds to 3 minutes. Gratz (1972) suggested a set-up time of 2 minutes. The remaining time, after deducting for alarm time, turnout time, access time and setup time is called travel time (Clet and Larson, 1998). This is the time measurement tool necessary to establish travel distance criteria for fire station locations (IAFC, 1995).

Considering the complexity of evaluating the many factors which affect the time necessary for responding equipment to set up for a fire, the IAFC (1995) studied these factors to established travel times for three different hazard classifications. These hazard classifications are the Minimum Risk Zone, Moderate Risk Zone and High Risk Zone. The Zones were defined as follows:

Minimum Risk Zone: Small commercial structures that are remote from buildings, detached residential garages, out buildings within other fire management zones.

Moderate Risk Zone: For an area to be classified as routine risk it should contain built up areas of average size, where the risk of life loss or damage to property in the event of a fire in a single occupancy is usually limited to the occupants, although certain areas, such as small apartment complexes, the risk of death or injury may be relatively high.

High Risk Zone: For an area to be classified as extra hazard or key risk, it should contain built-up areas of substantial size with a high concentration of property presenting substantial risk of life loss, a severe financial impact on the community or unusual potential damage to property in the event of fire. (p. 6-10)

Further, the IAFC (1995) recommends the following travel times for fire response to these zones:

Minimum Risk Zone: The prescribed travel time for minimum risk should not exceed six minutes.

Moderate Risk Zone: The prescribed travel time for moderate risk should not exceed five minutes.

High Risk Zone: The prescribed travel time for high risk should not exceed four minutes. (p. 6-10)

Determining the travel distance from a fire station from the time established for the Risk Zones, along with responses to EMS incidents, becomes a mathematical problem. “Studies have shown that the average speed of fire apparatus on roadways is 35 mph” (“Self Assessment,” 1995, p. 6-40). The IAFC (1995) reported that this equates to 53.1 feet per second.

A review of travel time would not be complete without considering the impact of natural and man-made barriers that affect travel time. Such barriers would include railroad crossings, drawbridges, narrow streets, high traffic density, one-way streets, low clearances, and areas subject to flooding. Consideration should also be given to delays in travel time caused by winter weather conditions (de Silva, 1995).

Further, in planning for fire station locations, McCarraher (1992) suggests that a “historical analysis over a period of the most recent three or four years” be completed (p. 8). This would provide a planning tool to add insight into the potential areas where a particular emergency may occur, based on previous history. A historical analysis of calls for service could also help to determine the availability of fire and EMS apparatus. This is because “as the number of emergency calls per day increases, the probability increases that a needed piece of apparatus will already be busy when a call is received” (Coughlin & Penner, 1991, p. 9).

While a historical record could help in determining future needs in emergency response, a recent report published by the United States Fire Administration (USFA) pointed to another factor that could also be an indicator of future fire activity. “Socioeconomic factors are among the best predictors of fire rates at the neighborhood level” (“TriData Corporation,” 1997, p. 25). The USFA (1997) report also stated that “virtually every study of socioeconomic characteristics has shown that lower levels of income are either directly or indirectly tied to an increased fire risk” (p. 2). Studies contained in this report, both in Newark, NJ, and Toledo, OH, also found that the average rates of fire were more than doubled in tracts of housing where low home ownership was indicated. Another report by the USFA (1998) added that “research has shown that these characteristics [demographic and socioeconomic] can be useful in predicting the magnitude and nature of fire problems in different neighborhoods…” (p. 4).

Given the many factors that contribute to travel times, many publications recommend the use of computer programs to best analyze fire station locations. Barr and Caputo (1997) wrote:

> With the advent of computer technology, the selection of fire station locations can best be determined with a greater degree of accuracy using geo-based information systems. Unlike previous methods that employed grid and concentric circle analysis, the computer programs simulate the real road network of the area being analyzed. A high degree of accuracy is ensured by using actual travel distances and vehicle speeds, factoring time delays for roadway conditions (e.g., congestion, turning radius, weather, hills etc.), accounting for one-way or unstable roadways, and implementing user-defined risk factors. (p. 10-252)

The literature review provided significant insight into the methods currently used to determine fire station locations. The traditional method of applying a standard travel distance from a location, using either the ISO schedule or what some have concluded as a recommend fire station location using the NFPA, is outdated. This was the method used to complete the 1998 City of Dover Master Plan. While many communities appear to still use these as standards, in full or in part, a more comprehensive analysis could be examined to determine fire station locations. Additionally, traditional standards do not necessarily apply when it comes to fire department based EMS systems. Determining travel time to an incident based on scientific testing provided a more qualitative process whereby fire officials, city planners, citizens and elected leaders will be able to choose a more appropriate level of service.

The literature review of natural and man-made barriers that can increase travel time provided a more realistic look into actual travel conditions and an increased awareness of barriers where travel could be delayed or even interrupted was noted. Understanding the relationship between previous calls for service and projecting future needs helped to identify locations where a need for service could be reasonably predicted and overall service workloads identified. A review of the relationship between demographics/socioeconomic factors and the potential for fire response helped to forecast projected needs for both fire and EMS services.

Finally, the literature review of computer software available to combine all these factors helped to develop an understanding of the number of factors that can be simultaneously considered by a computer, with specific software, to provide a more comprehensive analysis of both fire and EMS station locations.

PROCEDURES

The review of the City of Dover's 1988 Master Plan and other pertinent literature was the first step in the research procedure. Literature reviews were conducted using the NFA's Learning Resource Library and the ICMA's InQuiry service for all relevant material relating to fire station locations. Additional literature was found in the City of Dover Fire & Rescue Service's library, the National Fire Protection Association Library, the New Hampshire Fire Academy Library, the Internet and in the possession of co-workers. Research on demographic, socioeconomic, traffic history, home owner-occupied statistics and computerized mapping were found in the Dover Planning Office. Statistical information regarding buildings in the city was found in the Dover Tax Office and through personal knowledge. Building construction statistics were obtained from the Building Department. Information relating to fire and emergency response history was developed by completing an analysis using the Dover Fire & Rescue Service's computerized incident reporting system. Literature that was found to be applicable to answer the two research questions was included in a systematic presentation in the literature review section of this research paper.

The 1988 Master Plan review indicated two standards for the placement of fire stations in choosing the location of the proposed north end fire station. Both of those standards were found to be outdated in effectively locating fire and EMS stations. Both the IAFC (1995) and the IAFF (1995) recommended using travel time based on flashover in a fire and irreversible brain death in cardiac arrest victims. This was a more current and scientific approach that lent itself to public decisions for fire and EMS service levels. From the recommendation of the IAFC and the IAFF, travel times to incidents were developed.

Step two of the process was to convert travel times recommended by the IAFC (1995) and the IAFF (1995) into travel distances. This process was accomplished using the times recommended by the IAFC (1995) for Risk Zones and for the BLS and ALS response times recommended by the IAFC (1995) and IAFF (1995). The travel speed, 35 MPH, cited by the IAFC (1995) was used.

To convert travel time to travel distance, travel times needed to be converted from minutes to seconds [distance times 60 seconds]. Multiply 53.1 feet per second, the distance traveled to maintain a speed of 35 miles per hour, times the recommended travel time, in seconds. This equals the total number of feet apparatus would travel in the recommended amount of travel time. Divide this number by 5280 feet, the number of feet in a mile. This number reflects the travel distance, in miles, that apparatus can travel, under perfect conditions, in the recommended travel time. A summary is provided as follows:

Response Type	Travel Time	Travel Distance
Minimum Risk Zone:	6 minutes	3.6 miles
Moderate Risk Zone:	5 minutes	3.0 miles
High Risk Zone:	4 minutes	2.4 miles
Basic Life Support:	2 minutes	1.2 miles
Advance Life Support:	6 minutes	3.6 miles

Step three of the process called for the identification of 15 key sites through the city and to determine the travel distance from South End Station, Central Station and the location of the proposed north fire station, to each of these 15 sites. Travel distances were calculated using the Dover's Geographic Information System (GIS), a computerized mapping program which is capable of providing a measurement of road traveling distance between locations, and provided by GIS Coordinator Christopher Parker (personal communication, July 14, 1998).

The 15 sites chosen for evaluation were based on a number of factors. The buildings or areas were selected that had a high incident of calls for EMS services or fell into the risk group of Moderate or High, or were determined to be low income area or a high rental property area. Categorizing which risk group an occupancy or area fell into was accomplished using the 12 years experience I had in conducting fire and life safety inspections within the city. Each building site chosen was a site in which I had personally performed a fire and life safety inspection and felt qualified to categorize. The Dover Planning Department provided information on low-income areas and owner-occupied verses rental areas of the city (B. Woodfuff, personal communication, July 9, 1998). Enough sites were chosen to ensure a good cross section of geographic areas within the city to evaluate deficiencies in responding to various areas. Historical analysis of calls for service gave an overview of past needs for service for projecting future needs ("Sunpro," 1998). The following is a summary of the evaluation of the 15 sites chosen.

Waldron Towers is a 3 ½ story, 84 unit elderly housing building that was built in 1975. It has no built in fire protection and is located in the center of downtown. More than 50% of the household incomes are low to moderate in this area. The department responded to 159 calls for service to this location in1997. A High Risk

Zone travel distance of 2.4 miles was assigned this building. Travel distance to this location was as follows: South End Station - 1.6 miles; Central Station - .5 mile and the proposed north end station - 2.2 miles. The travel distance for fire response and ALS was found to be acceptable from all three sites. The travel distance to this facility for BLS was satisfactory only from Central Fire Station.

Central Towers is a 6 story, 70 unit elderly housing building that was built in 1964. It has no built in fire protection and is located in the center of downtown. The department responded to 90 calls for service to this location in1997. A High Risk Zone travel distance of 2.4 miles was assigned this building. Travel distance to this location was as follows: South End Station - 1.5 miles; Central Station - .4 mile and from the proposed north end station - 2.3 miles. Travel distance for fire response and ALS was found to be acceptable, the travel distance to this facility for BLS was satisfactory only from Central Fire Station.

Heritage Hill Apartments consists of 125 units located in eight, closely spaced buildings built in 1970. The buildings have no built in fire protection and are located on 9.3-acres in the eastern section of the city. More than 50% of the household incomes are low to moderate in this area. The department responded to 27 calls for service to this complex in1997. A High Risk Zone travel distance of 2.4 miles was assigned this building. Travel distance to this location was as follows: South End Station – 2.3 miles; Central Station - .7 mile and from the proposed north end station – 2.3 miles. While the travel distance for fire response was acceptable from Central Station, it was marginal from South End and the proposed north end site.

Advance life support was found to be acceptable from all three sites but the travel distance for BLS to this complex was acceptable only from Central Fire Station.

Wentworth-Douglas Hospital is a fully accredited, full service, 158-bed hospital. Originally constructed in 1952, extensive remodeling and additions have been made over the years. The building is equipped with automatic sprinklers and a smoke detection system. The department responded to 61 calls for service to this location in1997. A High Risk Zone travel distance of 2.4 miles was assigned this building. Travel distance to this location was as follows: South End Station – 2.7 miles; Central Station – 1.1 miles and from the proposed north end station – 1.6 miles. Travel distance for fire response was acceptable from Central Station and the proposed north end station. Consideration of ALS and BLS to the facility did not apply.

Langdon Place is a combination retirement home and nursing care facility. It has 40 private apartments and 24 nursing care units. Originally constructed in 1989, an extensive addition was added to care for 54 special needs patients. The building is equipped with automatic sprinklers and a smoke detection system. The department responded to 29 calls for service to this location in1997. A High Risk Zone travel distance of 2.4 miles was assigned this building. Travel distance to this location was as follows: South End Station – 1.5 miles; Central Station – 1.8 miles and from the proposed north end station – 3.3 miles. Travel distance for fire response was acceptable from Central Station and South End Station. Advanced life support care could be provided from Central Station and South End Station.

Consideration of BLS travel distance to the facility did not apply because of BLS trained on-site staff.

Riverside Rest Home is a Strafford County operated 205-bed nursing care facility. Part of a series of attached complex of buildings, the County also operates a 59-cell prison, a resident drug and alcohol rehabilitation center and a day-care center on the same site. The Rest Home was originally constructed in 1890 but extensive remodeling was completed in 1976. The building is equipped with automatic sprinklers and a smoke detection system. The department responded to 40 calls for service to this location in1997. A High Risk Zone travel distance of 2.4 miles was assigned this building. Travel distance to this location was as follows: South End Station – 5.4 miles; Central Station – 3.9 miles and from the proposed north end station – 2.1 miles. Travel distance for fire response was acceptable from the proposed north end. Advanced life support care could be provided from the proposed north end site only. Consideration of BLS travel distance to the facility did not apply because of BLS trained on-site staff.

Country Club Drive was chosen for two reasons; it represents an eastern portion of the city so that travel distances to this area could be reviewed and because more than 50% of household incomes in this area are low to moderate. The department responded to 444 calls for service to census tract location in1997. A Moderate Risk Zone travel distance of 3.0 miles was assigned this area. Travel distance to this location was as follows: South End Station – 3.1 miles; Central Station – 1.5 miles and from the proposed north end station – 3.3 miles. Travel distance for fire response and BLS was acceptable only from Central Station. Travel distance for ALS was acceptable from all three locations.

Cochecho Falls Millwork is the heart of the downtown. The Mill, a 9 ½ acre, 5-story mill building was built in 1909 and substantially renovated in the late 1980s and early 1990s. Consisting of three attached buildings, each separated by three-hour fire wall, the Mill is equipped with an automatic sprinkler system. Most recently occupied by 1,000 employees of a major insurance company, it is now occupied by multiple tenants. The department responded to 32 calls for service to this location in1997. A High Risk Zone travel distance of 2.4 miles was assigned this building. Travel distance to this location is as follows: South End Station – 1.5 miles; Central Station – .6 mile and from the proposed north end station – 2.3 miles. Travel distance for fire and ALS response was acceptable from all three sites. Travel distance for BLS was acceptable only from Central Station.

Faraday Drive is the furthest most street located in the western industrial park. The area is made up of medium and large size industrial buildings, most of which are equipped with an automatic sprinklers. The department responded to this census tract area 421 times in 1997. A Medium Risk Zone travel distance of 3.0 miles was established for this area. Travel distance to this location was as follows: South End Station – 4.1 miles; Central Station – 4.2 miles and from the proposed north end station – 5.9 miles. The area is not within travel distance for fire, ALS or BLS response criteria.

Ham Street is a residentially populated area and was chosen because of the fire history of this area and its high rental rate. Over the past ten years, this area of the city has been the site of a number of major fires. The most significant was a 1994 conflagration resulting in the damage or destruction of eight buildings. Additionally, this area consists of a high ratio of rental occupancies, 881 owner occupied to 1366 rental units. The department responded to 854 calls for service to this census tract in1997. A Moderate Risk Zone travel distance of 3.0 miles was assigned this area. Travel distance to this location was as follows: South End Station – 2.1 miles; Central Station – .5 mile and from the proposed north end station – 1.9 miles. Travel distance for fire and ALS response was found to be acceptable from all three sites. Travel distance for BLS was acceptable only from Central Station.

Lincoln Street is a residentially populated area and was chosen because the area consists of a high ratio of rental occupancies, 398 owner occupied to 1030 rental units. The department responded to 472 calls for service to this census tract in1997. A Moderate Risk Zone travel distance of 3.0 miles was assigned this area. Travel distance to this location was as follows: South End Station – 1.9 miles; Central Station – .3 mile and from the proposed north end station – 1.6 miles. Travel distance for fire and ALS response was found to be acceptable from all three sites. Travel distance for BLS was acceptable only from Central Station.

Allan Street is a residentially populated area located in the north end of the city. This area was chosen because of the low water pressure found in this area. The low water pressure could have an effect on firefighting capabilities. The department responded to 421 calls for service to this census tract in1997. A Moderate Risk Zone travel distance of 3.0 miles was assigned this area. Travel distance to this location was as follows: South End Station – 4.7 miles and the Central Station – 3.1 miles; and from the proposed north end station – 2.3 miles. Travel distance for fire and ALS response was found to be acceptable from Central Station and the proposed north end site. Travel distance for BLS was acceptable only from the proposed north end site.

Newick's Family Restaurant is a landmark in the city and represents the southern most business in the city. After burning to the ground in 1984, it was rebuilt and is now equipped with an automatic sprinkler system. The department responded to 17 calls for service in this area in1997. A Medium Risk Zone travel distance of 3.0 miles was assigned this building. Travel distance to this location was as follows: South End Station – 6.0 miles; Central Station - 6.6 miles and from the proposed north end station – 8.4 miles. Travel distance for fire response, BLS and ALS was found to be unacceptable.

River Street runs parallel with the Cochecho River and is the current location of Dover's Community Services' Public Works compound and is soon to be vacated for a new site. Planning is currently underway for the redevelopment of this property to establish a waterfront district within the city. Though still in the planning stage, depending on the type of development chosen, it could have an impact on the delivery of fire and medical services. There is also a high rental rate in this area, 669 owner occupied to 1467 rental units. Travel distance to this location was as follows: South End Station – 1.4 miles; Central Station - .7 mile and from the proposed north end station - 2.4 miles. Travel distances from all three locations would accommodate a High Risk Zone and ALS service. Acceptable travel time for Basic Life Support could only be provided from Central Fire Station.

The Oak Street and Portland Avenue area of the city contain the city's Olympic sized pool, Ice Arena and recreation fields. This is also the city line for a bordering town jurisdiction. There is also a greater ratio of renters to owner occupied occupancies, 532 renters to 223 owner occupied. The department responded to 444 calls for service to this census tract in 1997. A Moderate Risk Zone travel distance of 3.0 miles was assigned this area. Travel distance to this location was as follows: South End Station – 2.4 miles; Central Station – 1.0 mile and from the proposed north end station – 2.7 miles. Travel distance for fire and ALS response was found to be acceptable from all three sites. Travel distance for BLS was acceptable only from Central Station.

As previously stated, all travel distance was based on a 35-mile per hour speed, with perfect conditions. Consideration must also be given to various barriers to response times that, in some cases, may significantly affect the response capabilities of one or more fire stations. There were four major barriers identified that affect meeting the 35-mile per hour response average.

The most significant barrier is the railroad tracks, which intersects Central Avenue and also Chestnut Street. When a train travels through the downtown, the city is effectively cut in half. In an interview, Steve Belforti from the Boston & Maine's Springfield Terminal, said that a train travels through Dover an average of eight times a day (S. Belforti, personal interview, July 23, 1998). In the planning stages is also a commuter train line that would make Portland, ME, to Boston, MA, trips through the city each day. This would significantly add to the travel times for responding equipment negotiating the railroad tracks in need of getting to their location. The train also interrupts traffic flow for the main artery running through the city well after it has departed.

Another barrier to response to the downtown area is the general traffic problems resulting from having one main thoroughfare through the downtown area. The problem is only getting worse. According to Dover Planner Bruce Woodruff, (B. Woodruff, personal interview, July 28, 1998), traffic counts on Central Avenue indicate some 20,248 vehicles travel the road each day. Additional increases in traffic of 4% a year over the next ten years are expected. The addition of three more traffic signals on Central Avenue over the past 10 years have further snarled traffic through downtown.

A third barrier to effective response from the proposed north end fire station is the road the responding apparatus must use to access the downtown. Sixth Street is the most direct access road from the proposed north end site. The road is somewhat narrow and travels through a mostly residential area. The posted speed limit is 30 MPH for normal traffic. Driving at a speed of 35-miles per hour on some sections of the road is not a safe speed for fire apparatus.

The fourth barrier to effectively maximize travel time is the weather. Being a New England city, Dover's average ambient temperatures are sub-freezing four months out of the year and snow can be expected for six months ("State of New Hampshire Home Page," 1998). Of course while road conditions are snow or ice covered, emergency response apparatus must be driven slower. Even though the roads are effectively plowed each winter storm, the accumulation of snow and ice on the roadsides throughout the winter months results in less available space for opposing and flow traffic. This hinders a driver's ability to get safely out of the way of responding apparatus.

LIMITATIONS

Interested readers will note that the ability to do a more comprehensive analysis on travel times could have been completed had a commercial fire station location software package been available. One such package, FLAME (1995), developed by BODE Research Group, Inc., was evaluated. The software company claims that FLAME is capable of performing billions of time and distance calculations to accurately determine travel time from all fire stations to every street block ("Flame Demonstration Disk," 1995). Due to budget constraints, the approval of the purchase ($499 in May 1998), was not given until July 20, 1998.

The limitation in evaluating travel time trends of the Dover Fire & Rescue Service was that no hard data was available to separate the total response time into necessary segments to determine the time taken to process the call, turnout time and travel time to the incident. Hard data is defined as "any time element that can clearly be reconstructed from electronic or mechanical devices that make an automatic indication of time once activated" (IAFC, 1995, p. 6-35). Such devices would include time stamps, computer entries and the like. Clet and Larson (1998) reported that the method of taking an average time from the time the call is received to the time the first arriving unit reports on-scene and calling this the response time is shortsighted. They went on to explain that response time performance consists of all three components and it is necessary to account for all three times separately if accurate travel times are to be measured.

Another limitation in calculating response time was that the Dover Fire & Rescue Service does not document time in minutes and seconds. The IAFC (1995) recommends that a "system that keeps time in seconds will be more satisfactory in developing averages over the time period of study, as compared to systems that record minutes only" (p. 6-35). The problem with not having available data in minutes and seconds can be illustrated as follows. A call for service is received by Dispatch at 8 minutes and 55 seconds after the hour and the first arriving unit signs on-scene at 10 minutes and 3 seconds after the hour. Using a system that will track minutes and seconds shows that the total response time for the unit is actually one minute and eight seconds. However, in a system that will only track minutes will show a response time to the same call as three minutes. Such significant differences when attempting to evaluate response times becomes critical.

Finally, no effort was made to include mutual aid fire station locations in this research paper.

RESULTS

The following results were documented based on the answers to the two research questions.

Question 1. What nationally recognized standard(s) apply to the locating of fire and emergency medical service stations? Plainly stated, “currently there are no national standards for either response times or travel time” (Barr & Caputo, 1997, p. 10-252). Referring to the ISO schedule that so many communities use to evaluate their fire protection system, Coggan (1995) was quoted as having written: “The current classification system is not intended to present a complete analysis of the public fire protection needs of a city and should not be used for such an evaluation” (p. 180). This was followed by Hickey’s (1993) observation that the 1980 ISO schedule was designed to protect the interests of the insurance industry and at the very least “alternative considerations should be understood and examined when fire station location is an issue” (p. 221). Holba (1980) simply stated that… “ISO, to my knowledge, has never claimed their grading schedule to be a design tool in the locating of fire stations” (p. 35).

The NFPA recommendation for fire station location, also cited in many fire station location studies, was shown not to be a recommendation at all. The NFPA Fire Protection Handbook, 14th Edition, pages 9-78 and 9-79, published in 1976 was the source quoted for the NFPA’s recommendation. These pages were simply providing an overview of the requirements of the then current ISO schedule requirements, the 1974 ISO schedule. The most recent Fire Protection Handbook was quoted as recommending that "essentially each community must decide the appropriate response and travel times for their community" (Barr & Caputo, 1997, p. 10-251).

This did not mean that there was no effective manner to plan or evaluate a fire station location. Significant work by Coughlin and Penner (1991), the IAFC (1995) and the IAFF (1995a) provided objective and quantitative benchmarks for fire station location. Couglin and Penner (1991), as well as the IAFC (1995), recommend travel time from fire stations to risk hazard buildings or areas based on the potential for flashover. Travel times, and subsequent conversion to travel distance, to the three Risk Zones from a fire station were recommended by the IAFC (1995) as follows:

Response Type	Travel Time	Travel Distance
Minimum Risk Zone:	6 minutes	3.6 miles
Moderate Risk Zone:	5 minutes	3.0 miles
High Risk Zone:	4 minutes	2.4 miles

Criteria for establishing fire station locations for emergency medical service units was different than that of fire apparatus. Both the IAFC (1995) and the IAFF (1995a) concur that response to cardiac arrest victims should be within four minutes for basic life support and eight minutes for advanced life support. This recommendation was based on scientific research which indicated that the chances for surviving a heart attack significantly decrees as each minute passes beyond the above prescribed times ("IAFF," 1995a). Irreversible brain damage occurs from four to six minutes after the heart stops pumping oxygenated blood to the brain (Grant, Murray & Bergeron, 1994). Travel times, and subsequent conversion to travel distance, for the two levels of EMS care recommended by the IAFF (1995a) are as follows:

Response Type	Travel Time	Travel Distance
Basic Life Support:	2 minutes	1.2 miles
Advance Life Support:	6 minutes	3.6 miles

Question 2. By applying these standards, would the building of a north end fire station at its projected site allow for the closing of the Central Fire Station? Applying the travel time criteria recommended by the IAFC (1995) and the IAFF (1995a) to various buildings and areas throughout the community revealed that certain high risk sites can not be effectively covered by a north end - south end fire station combination. Couple this with the four barriers to effect response and an even increased number of evaluated sites would have fallen short of the IAFC and IAFF recommendations for fire response times. Of particular note was that the ability to provide effective BLS care in the recommended four minute travel time frame would be especially compromised if Central Fire Station were to be closed.

Table 1 gives a summary of the travel distance and the ability of providing services were Central Station to be closed.

Table 1
Response Capabilities without Central Fire Station

Location	Fire Services	ALS Services	BLS Services
Waldron Towers	Yes	Yes	No
Central Towers	Yes	Yes	No
Heritage Hill Apartments	Marginal	Yes	No
Wentworth-Douglas Hospital	Yes	N/A	N/A
Langdon Place	Yes	Yes	N/A
Riverside Rest Home[a]	Yes	Yes	N/A
Country Club Drive	No	Yes	No
Cochecho Falls Millwork	Yes	Yes	No
Faraday Drive[a]	No	No	No
Ham Street	Marginal	Yes	No
Lincoln Street	Yes	Yes	No
Allan Street[a]	Yes	Yes	No
Newick's Restaurant[a]	No	No	No
River Street	Yes	Yes	No
Oak Street & Portland Street	Marginal	Yes	No

[a]North end areas not affected by Central Fire Station closing either way.

Additionally, with increased frequency, back-to-back calls are being received. In the previous 10 years, the Dover Fire & Rescue Service has experienced an increase in calls for service from 3,376 in 1988 to a projected 4,640 for 1998. This should not be unexpected because from January, 1989 - July, 1998, the total number of new single-family homes increased by 684, new rental units increased by 398 units and 22 new commercial buildings were built (T. Clark, personal communication, July 15, 1998). This increased demand for service splits the available resources available for response with greater frequency, further jeopardizing the ability to meet critical time criteria.

As a result of the above-mentioned facts, Central Fire Station should remain open if critical travel distance criteria is to be met.

An unexpected finding was that the recommendation from the National Fire Protection Association for travel distances found in the 1988 City of Dover Master Plan, and also a number of National Fire Academy Applied Research Projects, magazine articles and community fire station location studies, was not a stated recommendation from the NFPA. One community's study actually called the supposed recommendation a "National Standards [sic]" ("Evanston Study," 1987, p. 28). The fact of the matter is that the NFPA clearly does not recommend any fire station travel distances in any edition of the Fire Protection Handbook.

DISCUSSION

In 1988, the City of Dover Master Plan was published. Among other planning recommendations, it contained a recommendation to build a new fire station in the north end of the city. An area for the proposed new fire station was chosen based on criteria used by the Insurance Services Office and recommended location criteria from the NFPA. The area chosen in the Master Plan was the area of Sixth Street, near the Sixth Street connector. In 1997, land was set aside by the Dover City Council for the proposed north end station on the Sixth Street connector. The developers of the Master Plan envisioned three fire stations to provide fire and EMS services to the city. At some point, the consensus of the current City Council changed to indicate that the city could be effectively served by two fire stations; one in the north end of the city and one in the south end. This change of opinion by the policy makers for the city leaders to an evaluative research project to determine whether the criteria used in developing the fire station site locations in the Master Plan were current and applicable.

Review of fire station location studies from other communities, spanning a decade of time, provided valuable insight into the various methodologies used for fire station location planning. It also provided a window into the progressive changes that have taken place during the same time span as has elapsed since Dover's Master Plan was last developed. The most significant changes found were in the use of computer mapping programs to realistically forecast travel distances. A significant amount of literature was reviewed relating to the subject of computer-based fire station location models; however, most of it was found to be obsolete and of not much use in this project.

Literature reviewed from Coggin (1995), Hickey (1993), and Holba (1980), pointed to the need to use an evaluation tool other than the 1980 ISO schedule for determining fire station locations. The general and broad-sweeping ISO schedule did not allow for consideration of many other factors that contribute to effectively establishing fire station sites. Literature from the National Fire Protection Association's Fire Protection Handbooks proved that the NFPA did not recommend the prescribed travel distances outlined in the Master Plan.

With both evaluation standards found to be deficient for evaluating fire station locations, other criteria needed to be found. Research conducted by Coughlin and Penner (1991), the IAFC (1995) and the IAFF (1995a) and others pointed to a need to intervene in a fire's growth prior to the advent of flashover. Failure to do so will result in a lost chance of rescuing victims in the area of fire origin and a decreased chance of prompt fire extinguishment. Research from a number of sources cited in the literature review, point to the need to provide basic life support to cardiac arrest victims in less than 4-minutes and advance life support in less than 8-minutes. For each additional minute that passes, the chance of survival decreases by 5.5%.

Using these times as benchmarks provided the basis for the minimum amount of service the fire and rescue department should provide. Anything less would result in a false sense of security by the citizens of Dover. Additionally, using these times as a benchmark would provide the City Council with reasonable, quantifiable standards to evaluate the community's fire and EMS response capabilities (Bruegman & Coleman, 1997). From this research, an informed decision by the City Council can be reached.

The consistent message found throughout the literature review was this; regardless of what method is used to evaluate fire station location or what research material is presented, it is the community that must decide what level of service it is willing to pay for.

Moreover, regardless of how effective, efficient and reliable a fire protection and EMS system is, there are just too many variables that contribute to the successful outcome of an emergency to provide any guarantees.

The study findings indicate that Central Fire Station should remain in operation. As a result, the fire department administration must work with the city planners to sufficiently inform the City Council as to why Central Station should remain open and the consequences were the station to close. It is important that the fire department administration provide operational expenses for the proposed addition of a fire station, to include staffing costs, so that the City Council can fully understand the financial impact of the cost of adding another fire station to the city. Finally, the fire department administrators need to evaluate equipment location to maximize the response capabilities at the lowest possible cost.

Failure on the part of the fire department administrators to successfully solicit support from the City Council for the continued operation of Central Station will result in a significant decrease in the effectiveness, efficiency and reliability of fire and EMS services in the City of Dover.

RECOMMENDATIONS

Based on the research and procedures followed in this paper, it is concluded that Central Fire Station should remain open after the north end fire station is built. Travel distance from the proposed north end site to the downtown, urban core of the community; the low to moderate income area; the areas with the highest rental property rates and east side of the city; would exceed the recommended travel time to effectively initiate suppression efforts prior to flashover. Additionally, travel time would be exceeded for effectual basic life support services to many more areas of the city. The existing traffic flow problems in the downtown would further hamper efforts for expedient response times. Travel distances from the proposed north end station do not sufficiently compensate for the areas that would be affected were Central Station to be closed.

Although there are no national standards for the location of fire stations, the IAFC (1995), recommends that a community establishes and adopts a statement of policy for travel time to include an element of time and performance expectations. These times should allow for a fire response to an area before flashover, basic life support in four minutes and advance life support in eight minutes. From these adopted time and performance objectives, a fire station location analysis should be completed that is in accordance with the adopted policies and procedures of the City Council. As such, it is recommended that the fire department administration submit to the Dover City Council for adoption the following five time and performance expectations:

(1) For 90% of fire responses to occupancies or areas classified as a Minimum Risk Zone, as classified by the Fire Chief or his/her designee, the first due unit shall arrive within 6-minutes travel time. The first-due unit shall be capable of advancing the first line for fire control or starting rescue operations.

(2) For 90% of fire responses to occupancies or areas classified as a Moderate Risk Zone, as classified by the Fire Chief or his/her designee, the first due unit shall arrive within 5-minutes travel time. The first-due unit shall be capable of advancing the first line for fire control or starting rescue operations.

(3) For 90% of fire responses to occupancies or areas classified as a High Risk Zone, as classified by the Fire Chief or his/her designee, the first due unit shall

arrive within 4-minutes travel time. The first-due unit shall be capable of advancing the first line for fire control or starting rescue operations.

(4) For 90% of emergency medical Basic Life Support care, the first due unit shall arrive within 2-minutes travel time. The first-due unit shall be capable of providing basic life support procedures for medical emergencies.

(5) For 90% of emergency medical Advanced Life Support care, the first due unit shall arrive within 6-minutes travel time. The first-due unit shall be capable of providing advanced life support procedures for medical emergencies.

The capturing of time data in the form of both minutes and seconds is a more accurate measurement tool. The Dover Fire & Rescue Service is not currently capable of capturing data in this format. It is recommended that the department explore the possibility of expanding its current incident reporting software to allow for the capturing of time in both minutes and seconds.

Currently within the City of Dover, response time is documented from the time a call for service is received to the time the first arriving unit reports on-scene of the incident. To further evaluate the effectiveness and the efficiency of the call processing time by the dispatchers and the turnout time by the responders it is recommended that these times be captured and documented separately. This would also allow for the actual travel time from the station to a particular location to be captured and documented to evaluate trends and procedures needing refinement or improvement.

Once this capability is established, benchmarks recommended by the IAFC (1995) should be adopted to carefully evaluate the efficiency of call processing time and turnout time. It is recommended that the following benchmarks be established for these functions:

Call Processing Time: The benchmark for this element of response time is a 50 second timeframe.

Turnout Time: The benchmark for this element of response time is a 60 second timeframe.

The final recommendation is that once the FLAME software package arrives, adequate time and resources be allocated for sufficient training and the necessary time to perform the required data entry. This data will serve as the foundation for a more comprehensive fire station location survey now and into the future. Using the information contained in this research paper and the computer mappings generated from FLAME, setup a workshop with the City Council, the City Manager, Fire & Rescue Administration and City Planners to openly discuss the future of Central Station.

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